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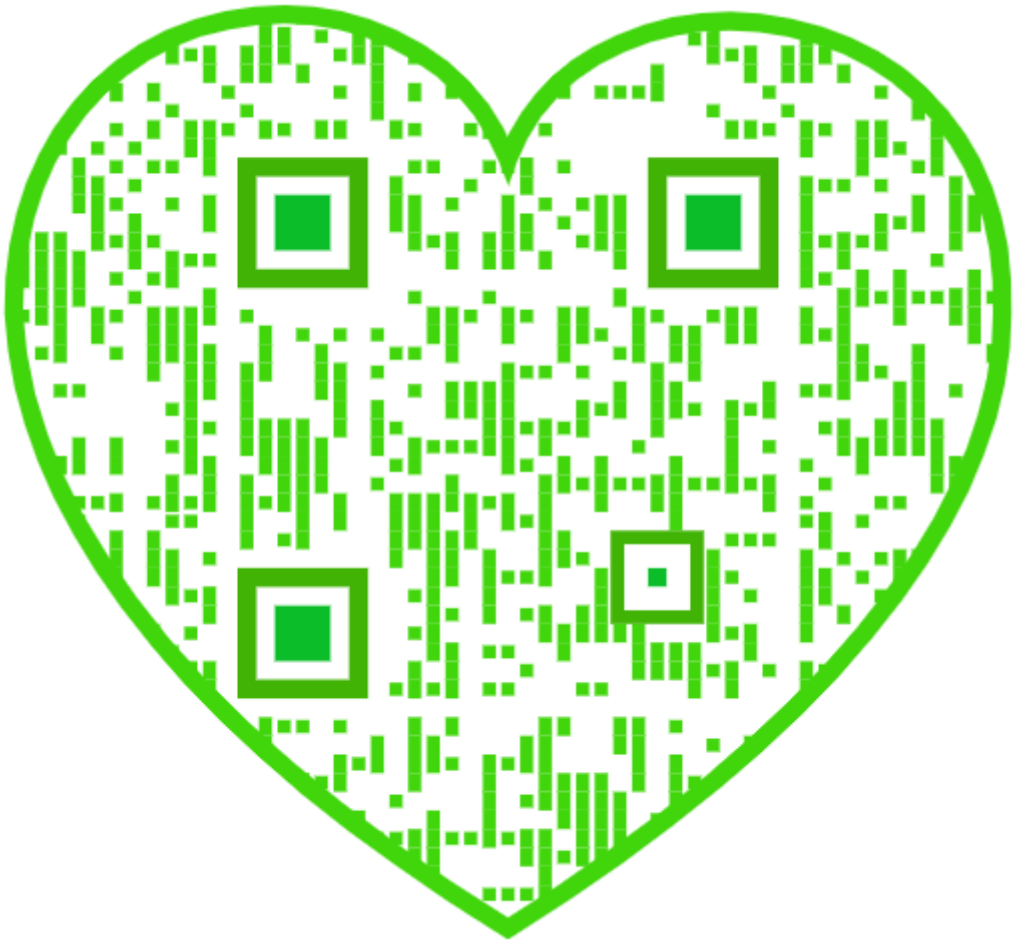

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STUDIES ON THE SANITATION OF SWIMMING POOLS

Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy, in the Faculty of Pure Science, Columbia University.

WALLACE A. MANHEIMER

Reprinted from
THE JOURNAL OF INFECTIOUS DISEASES, Vol. 15, No. 1, July, 1914, pp. 159-186

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STUDIES ON THE SANITATION OF SWIMMING POOLS

WALLACE A. MANHEIMER.

(From the Laboratory of the Department of Bacteriology, College of Physicians and Surgeons, Columbia University, New York.)

The present investigation was undertaken to inquire into the sanitary conditions existing in swimming pools, and to study methods of improving these pools if defective, without altering too greatly their equipments or modes of administration. In addition to this, it has been our purpose to determine as accurately as possible, standards in construction, equipment, and management which we think should be required of such establishments in the future.

The problem of the sanitary swimming pool has assumed considerable importance. The dangers of bathing in polluted water have been pointed out by many authors, and numerous plans for overcoming these dangers have been suggested. Many municipalities have established public baths and swimming pools. Swimming pools have been installed by private individuals, as well as by colleges and universities, secondary and elementary schools, clubs, steamship companies, and Turkish and Russian bathing establishments. National and international associations[1] have been formed, to promote the movement. The increased interest taken in the sanitary condition of the pools is an indication of their growing popularity, and therefore of the practical importance of the subject.

That the swimming pool is actually a medium for the transmission of disease, has been well pointed out by Atkin[2] who divides diseases communicable from pool into three classes: (1), intestinal, (2) eye and ear, and (3) venereal. We follow his classification in the succeeding paragraphs.

1. *Intestinal infections.*—Jäger[3] reported the occurrence of an intestinal proteus infection among ten soldiers in the garrison of Ulmer, who had bathed in the river Danube. Two of the patients died. The infection was traced to an epidemic of fowl disease in a village situated on a tributary of the Danube, a short distance above the place where the soldiers had bathed. Jäger found

1. The American and The International Association for Promoting Hygiene and Public Baths.
2. *Proc. Ill. Water Supply Assoc.*, 1911, 3, p. 73.
3. *Ztschr. f. Hyg. u. Infectionskrankh.*, 1892, 12, p. 525.

the bacilli in the water of this tributary, in the feces of the patients, and in the bodies of the dead fowls.

Drescher[4] isolated a type of proteus bacillus from the water and from the feces of the patients during an epidemic among 38 soldiers who had bathed in the Neise. After the bathing in this river had been stopped the epidemic subsided.

Pfuhl[5] attributed 49 cases of typhoid fever to bathing in the Elbe at Altona. Lenhartz[6] gave an account of a case of typhoid fever in a man who had fallen into the Elbe and swallowed considerable water. Klein and Schütz[7] reported cases of typhoid fever in 6 soldiers who had bathed in water close to the mouth of a city drainage canal. In the discussion of a paper by Maier,[8] Dr. Reece reported the occurrence of 34 cases of enteric fever among soldiers who had bathed in a swimming pool which derived its water from a sewage-polluted river. About 10 per cent of the men using the pool became infected, while only one case developed among those who did not use the pool. The epidemic ceased when bathing in the pool was discontinued.

In Japan, Shiga investigated an epidemic of 413 cases of dysentery in the village of Mitaknura. Near the town was a river in which bathing had been prohibited. When this restriction was removed, hundreds of persons went swimming, and within four days the epidemic broke out. It was found that the clothes and bedding of a person, who had died of the disease, had been washed in the water of the stream a short distance above the village. Shiga concluded that the epidemic was due to the ingestion of the river water by bathers.

Shäfer,[9] Witte,[10] Kirchner,[11] Hartog,[12] Bassin,[13] Baginsky,[14] and others have further advanced presumptive evidence that intestinal diseases can result from bathing in polluted water.

2. *Eye and ear infections.*—Fehr[15] tells of 20 cases of eye infection among patrons of a public swimming pool, and in one case reinfection occurred as a result of subsequent swimming in the same pool. Schultz[16] reported 18 cases of trachoma among the young men who had used a public swimming pool which had been contaminated by an attendant who had sore eyes. Cobb[17] reported two cases of ear infection from the use of a swimming pool. In one case the boy was infected three consecutive times from the same pool.

3. *Venereal diseases.*—Hertzka[18] and Sticker[19] have demonstrated that *B. prodigiosus* can pass into the vagina of women while swimming. Skutch[20] has reported an epidemic of gonorrheal vulvovaginitis which spread to 236 girls in a school at Posen. They had all used the same swimming pool, but not the

4. *Sanitätsber. über d. kgl. Preuss. Armee,* 1898.
5. *Deutsche Mil. Wchnschr.,* 1888, 17, p. 9.
6. *München. med. Wchnschr.,* 1892, 6, p. 898.
7. *Wien. med. Wchnschr.,* 1898, 6, p. 238.
8. *Proc. Roy. Med. and Chir. Soc., London,* 1908, 2, p. 227.
9. *Deutsche Mil. Wchnschr.,* 1890, 36, p. 39.
10. *Sanitätsber. über d. kgl. Preuss. Armee,* 1898.
11. *Deutsche Mil. Wchnschr.,* 1888, 17, p. 95.
12. *Sanitätsber. über d. kgl. Preuss. Armee,* 1897.
13. *Ibid.,* 1896.
14. *Hyg. Rundschau,* 1896, 6, p. 597.
15. *Berl. klin. Wchnschr.,* 1900, 1, p. 37.
16. *Ibid.,* 1899, 39, p. 36.
17. *Boston Med. and Surg. Jour.,* 1908, 159, p. 9.
18. *Monatschr. f. Geburtsh. u. Gynäk.,* 1902, 16, p. 3.
19. *Ztschr. f. Geburtsh. u. Gynäk.,* 1901, 45, p. 510.
20. *Centralbl. f. Bakteriol.,* 1892, 12, p. 309.

same towels, soap, etc. Rosenau states: "Gonorrhea is usually transmitted by sexual congress; however, accidental or innocent infections are not infrequent." Paul Bending[21] reports the case of 40 girls sent for convalescence to a brine bath, 15 showed signs of gonorrhea after the return. The infection came from an 8-year-old girl, who apparently had been suffering from gonorrhea for several years, and the disease was spread through indiscriminate bathing in one bath-tub and the use of the same bath towel.

That swimming pools can transmit disease, then, has been actually demonstrated. When, therefore, the use of the swimming pool is made compulsory, as it is, for example, in secondary schools in New York state, it would seem just that the authorities imposing this condition, be compelled to exercise sanitary supervision, and be held responsible for accidental infections traceable to defective sanitary management.

IMPORTANCE OF ANALYSIS FOR INTESTINAL BACTERIA

The final decision concerning the sanitary condition of a swimming pool must be based upon bacteriological examinations. The appearance of the water is practically of no significance, since it may be clouded by organic or inorganic matter in suspension. In our own investigations, pools that were dirty in appearance were often found to be relatively free from bacteria, and vice versa. Atkin[22] and Manheimer[23] have pointed out that chemical analysis alone is of no value in determining the sanitary condition of the swimming pool water, since the large quantity of organic matter added by each swimmer makes the interpretation of the analysis difficult. Unlike the chemical analysis of drinking water, in which such analyses may be of considerable importance, it is worthless in the case of water of swimming pools. Bacteriological investigation therefore remains the only reliable index.

A review of the literature indicates that the most important diseases transmitted through the agency of the swimming pool are those which affect the intestinal canal. Typhoid fever and diarrheal conditions attributed to *B. proteus* and some other bacteria have been traced to swimming pool infection on reasonably reliable evidence. This being the case, the examination of the swimming pool water for colon bacilli as an index of pollution becomes as logical a method of control as it does in the control of drinking water.

Colon bacilli are usually absent in 1 c.c. of drinking water in and about New York City. This fact has been established by the repeated routine analyses of the Department of Water Supply, Gas, and Electricity, as well as by our own examinations, and, on the basis of such measurements, comparative examinations of the swimming pool waters may easily serve to determine the degree of pollution.

In New York City the question of typhoid fever assumes especial importance since the disease seems to be endemic. Jackson in his report to the

21. *München. med. Wchnschr.*, 1909, 56, p. 1864.
22. *Proc. Ill. Water Supply Assoc.*, 1911, 3, p. 73.
23. *Am. Phy. Ed. Rev.*, 1912, 17, p. 669.

Merchants' Association of New York[24] attributes this to the fact that the tides are not sufficiently strong to carry away the solid masses of sewage, and, in consequence, masses of human excreta accumulate along the shores when the tide falls. In summer these are covered with flies and form a constant menace. The report of the Metropolitan Sewage Commission[25] also largely attributed the prevalence of typhoid fever to the vast quantity of sewage-polluted water that surrounds the city. Altho this condition may account for some of the cases, the pollution of swimming pools by typhoid carriers must be looked upon as a constant and important danger. That the typhoid carrier state is not as uncommon as was formerly supposed is evident from the numerous studies recently made. Since it would be hopeless for technical reasons (here, as well as in the case of drinking water) to rely upon the actual determination of typhoid bacilli themselves, the general index of pollution furnished by the colon test seems to offer the best means of controlling pollution. Unlike drinking water, in this case we can definitely exclude contamination from any but a human source. This exclusion increases the value of the examination, and standards of safety can be established.

Formerly, most of the endemic typhoid fever was attributed to the ingestion of polluted water. At the present time, it appears that the disease remains endemic largely because of the constant foci of infection supplied by temporary and permanent bacillus carriers. Russell[26] states: "In the southwestern part of Germany many bacillus carriers have been found, and the authorities have, at present, about three hundred of such persons under observation. Many, after a time, cease to be carriers, but new ones are continually being discovered, and so the number remains constantly high." Rosenau states that 4 per cent of all typhoid fever patients continue to discharge typhoid bacilli in the urine or feces, during and after convalescence. Albert states that 25 per cent of all chronic typhoid carriers have never had typhoid fever, and further estimates that 1 in every 1,000 of the general population is a carrier.

The very thorough studies of Rosenau, Lumsden and Kastle,[27] and of Lumsden and Anderson[28] on the rôle played by bacillus carriers in the spread of typhoid infection in the city of Washington, deserve especial attention. In 1908 these investigators examined the feces of a thousand different persons in apparently good health, or with maladies not suggesting typhoid fever. The results of their examinations indicated that 0.3 per cent of the general population of Washington became temporary typhoid bacillus carriers. In their search for chronic bacillus carriers, they examined 307 specimens of urine and feces of persons who had had the disease, and found that 8, or 2.8 per cent of these individuals were discharging typhoid bacilli. When one considers the difficulty of isolating typhoid bacilli from feces, and also the fact that carriers sometimes fail to discharge bacilli for considerable lengths of time, the estimation of the Washington investigators must be considered extremely conservative. In this connection it is well to mention Park's interesting case of "Typhoid Mary"[29] who infected twenty-six persons, some fatally, with typhoid fever. Bolduan and Noble[30] report the case of a dairyman who unwittingly dissemin-

24. *Merchants' Assoc. of N. Y.*, 1909.
25. *Rept. Metropol. Sewage Com. N. Y. City*, 1908.
26. *Mil. Surgeon*, 1909, 24, p. 53.
27. *Bull. Hyg. Lab., U. S. P. H. S.*, 1909, No. 53.
28. *Ibid.*, 1911, 78.
29. Pathologic Bacteria and Protozoa.
30. *Jour. Am. Med. Assn.*, 1912, 58, p. 7.

ated typhoid germs for forty-eight years. The literature of this subject has been fully reviewed by Ledingham[31] and Grimm.[32]

The connection of the foregoing considerations to the problem of the sanitation of the swimming pools is clear, and renders the determination of the degree of pollution by organisms that produce intestinal infections a matter of great importance.

LITERATURE AND FACTORS OF IMPORTANCE IN SWIMMING POOL SANITATION

The literature on swimming pools is not very extensive. Moreover, the points of view from which pool sanitation has been studied are so various that we can best survey the work that has been done by classifying it according to the particular features of this problem with which each writer has concerned himself. The factors involved in the control of swimming pools consist of: (1) construction and equipment, (2) attention to the source of water, (3) management of the water, i.e., filtration and refiltration, etc., (4) chemical disinfection, and (5) administration. Judgment of the efficiency of any or all of these factors can be formed only by (6) bacteriological control which, therefore, we classify as a sixth important feature in sanitary management.

1. *Construction and equipment.*—Only brief mention of the structural features of swimming pools can be made in this paper. However, the details of construction are as essential to the sanitary efficiency as chemical treatment of the water or any other sanitary measure. Without entering at length into this subject we may summarize the chief sanitary features of construction and equipment of swimming pools as follows: the smoothness of the lining, lack of obstructions in the water, the presence of a combination of surface-overflows and life rails, adequate shower-bath and toilet facilities, and an efficient filtration plant.

2. *Attention to the source of water.*—It is perfectly obvious that the original water must be pure in a sanitary swimming pool. Manheimer[33] has shown that the water used in many out-of-town pools was of very poor quality. The summary of his results: number of pools using city and town supplies, 22; well water, 5; lake water, 4; river water, 2; creek water, 2. The lake, river and creek waters used, contained a considerable amount of sewage, while in two cases the State Department of Health had condemned the town supplies.

3. *Management of the water.—Refillings.*—Earlier writers, as Edel,[34] Hesse,[35] and others[36] have dwelt on the importance of frequent refillings. Manheimer[37] has more recently found that there is no direct relation between the number

31. *Rept. of Local Gov. Bd. of Eng. and Wales,* 1909, 38, p. 82.
32. *Pub. Health Repts.,* 1911, Washington, 26, p. 313.
33. *Am. Phy. Ed. Rev.,* 1912, 17, p. 669.
34. *Arch. f. Hyg.,* 1893, 19, p. 225.
35. *Ztschr. f. Hyg. u. Infectionskrankh.,* 1897, 25, p. 482.
36. *Hyg. Rundschau,* 1908, 18, 1391.
37. *Am. Phy. Ed. Rev.,* 1912, 17, p. 669.

of weekly refillings and the sanitary condition of the water of a swimming pool.

Dilution.—Manheimer[38] has reported upon the effects of dilution in several pools. It appears that dilution of the water of a swimming pool is efficient, tho expensive.

Refiltration.—Schwartz[39] in 1905, was the first to investigate the refiltration of pool water. Kister and Fromme[40] highly advocated refiltration, and in addition to this, advised refillings every three weeks, with also the addition of considerable amounts of dilution water. Angel[41] in a paper read in 1908, concluded that refiltration improved the appearance and bacteriological condition of the water, and also reduced the cost of maintenance. Crane[41] and Manheimer[43] both recommended refiltration when combined with other methods.

4. *Chemical disinfection.*—Methods similar to those proposed for the purification of drinking water have been suggested for the chemical disinfection of the water of swimming pools. The first attempt in this direction was that of Stokes[44] who used copper sulphate to purify a Baltimore swimming tank and obtained destruction of bacteria and algae using 1 part of copper sulphate to 100,000 parts of water. Alexander[45] reported satisfactory results from the use of magnesium hypochlorite derived by electrolysis from a chemical containing magnesium chlorid. All other writers on this subject have recommended the use of calcium hypochlorite.[46] Burrage, in 1909 at Purdue University, made careful analyses of the bacterial condition of the water before and after disinfection with calcium hypochlorite. Following the recommendations formulated for the disinfection of drinking water by Woodhead[47] and others[48] he used one part of available chlorin[49] to one million parts of water. The counts, which averaged about 100,000 bacteria per c.c., were reduced by this means to between 0 and 26 per c.c. Bunker[50] in 1910, showed that with one part of available chlorin to a million parts of water, sterilization was effected in 15 minutes. Atkin[51] in 1911, was successful when using 1 part of chlorin to

38. *Ibid.*
39. *Gsndhts Ingenieur,* 1910, 30, p. 30.
40. *Ibid.*
41. *Assn. Mun. and County Eng.,* 1908, 34, p. 960.
42. *Eng. List,* 1912, 21, pp. 11, 43. *Proc. Am. Assn., Promote Hyg. and Pub. Baths,* 1913.
43. *Am. Phy. Ed. Rev.,* 1912, 17, p. 669.
44. *Am. Med.,* 1905, 10, p. 1075.
45. *Scient. Am. Supp.,* 1909, 68, p. 1765.
46. The following are some of the cities in the United States and Canada, that use calcium hypochlorite for the purification of the drinking water: New York City, Jersey City, Council Bluffs, Brainerd, Erie, Montreal, Milwaukee, Cleveland, Ridgewood, Corning, Omaha, Nashville, Grand Rapids, Little Falls, Harrison, Baltimore, Cincinnati, Toronto, Niagara Falls, Minneapolis, Pittsburgh, Rahway, Hackensack, Ottumwa, etc. (Hooker).
47. *Jour. Roy. San. Inst.,* 1910, 31, p. 281.
48. *Ztschr. f. Hyg. u. Infectionskrankh.,* 1895, 20, p. 227. *Lancet, London,* 1908, 2, p. 1597. *Pub. Health, London,* 1909, 23, p. 350. *Ztschr. f. Hyg. u. Infectionskrankh.,* 1894, 16, p. 149.
49. $CaOCl_2$, calcium oxychlorid, is generally accepted to be the essential constituents of dry chlorid of lime. It is soluble in about twenty times its weight of water, leaving a small insoluble residue, mostly calcium hydroxid: In an aqueous solution, calcium hypochlorite forms the only valuable constituent, the calcium chlorid being inert and valueless. The reaction in water is $2CaO.Cl_2=CaCl_2+Ca(OCl)_2$ (calcium hypochlorite).

From solution of hypochlorites, carbonic acid contained in the water will liberate free hypochlorous acid ($Ca(OCl)_2+H_2CO_3=2HOCl+CaCO_3$); the hypochlorous acid is the active oxidizing agent. It is clear from this, that the term "parts of available chlorin" is an expression used merely for convenience, and does not refer in any sense to the chemical reaction.
50. *Am. Jour. Publ. Health,* 1910, 20.
51. *Proc. Ill. Water Supply Assoc.,* 1911, 3, p. 73.

a 1,000,000 parts of water, but found that the effect of the hypochlorite was unsatisfactory when 0.5 part was used. Whipple,[52] Lewis,[53] Rettger and Markley,[54] Lyster,[55] Tully,[56] *The Engineering Record* (unsigned),[57] Manheimer,[58] Ravenel,[59] Markley,[60] Bunker and Whipple,[61] all have recommended the use of calcium hypochlorite for swimming pool disinfection on the basis of tests of its efficiency. More recently Buswell[62] in 1913, following the work of Darnall,[63] suggests the use of anhydrous chlorin[64] as being more effective for bacterial destruction, easier of application in the pool he examined, and more constant in composition than calcium hypochlorite. He objects to the hypochlorite chiefly because of lack of constancy in composition.

5.—*Administration.*—Manheimer[65] has compared the sanitary condition of several pools that were operated in about the same manner, and had approximately the same cubic capacities. He found that the administration of the pool, the supervision of the working force, the inspection of the bathers before entering the water, and their instruction in pool sanitation were the most important agencies in keeping the bacterial counts low.

To complete the review of the literature of this subject, it is well to mention the papers of Roberts and Porter. Roberts,[66] besides urging the use of calcium hypochlorite, suggests the use of isotonic salt solution instead of common water for tanks, as the solution is less irritating to the mucuous membranes. He also suggests a circulating pump to insure the immediate distribution of added germs. Porter[67] confines himself in his paper to a careful consideration of the dangers associated with unsanitary pools, without considering recommendations for their control. A large part of his interesting communication relates to the "Kosher" baths used by the poorer class of Jewish people on the lower East Side of New York City. At his suggestion this investigation was taken up by us, and Porter's results will be discussed below.

PLAN OF STUDY

Our own plan of investigation consisted in making periodical bacteriological examinations of a considerable number of pools and Mikveh baths, attempting to find methods of operation that might be applied to the sanitary management of swimming pools in general. In addition to this, it has been our aim to correct individual procedures where these have been found faulty.

52. *Mun. Jour. and Engin.,* 1911, 31, p. 577.
53. *Eng. News,* 1911, 65, p. 636.
54. *Ibid.,* 66, p. 699.
55. *Jour. Am. Med. Assn.,* 1911, 57, p. 1992.
56. *Am. Jour. Pub. Health,* 1912, 11, p. 1186.
57. *Engineer Rec.,* 1912, 65, p. 699.
59. *Ibid.,* p. 684.
58. *Am. Phy. Ed. Rev.,* 1912, 17, p. 669.
60. *Ibid.,* 1913.
61. *Ibid.,* p. 75.
62. *Ibid.,* p. 395.
63. *Jour. Am. Pub. Health Assn.,* 1911, 17, p. 78.
64. Anhydrous chlorin sterilizes by means of its nascent chlorin, whereas, chlorid of lime acts by means of the nascent oxygen liberated from hypochlorous acid. (See footnote above.)
65. *Am. Phy. Ed. Rev.,* 1912, 17, p. 669.
66. *Eng. News,* 1912, 67, p. 73.
67. *Survey,* 1912, 28, p. 588.

TECHNIC OF BACTERIAL WATER ANALYSIS

Collection of samples.—Samples were collected from the surface, middle-depth, and bottom of the pools, except in cases mentioned in the text. The collection of these samples was always from the deep end of the pool. A weighted bottle (Abbott) was used for the collection of bottom and mid-depth samples, and a glass-stoppered one held by means of a bent wire for surface collections.

The tops of all bottles were wrapped in stiff brown paper, to protect the necks and lips from dust. The bottles were then sterilized in the hot air oven for one hour, at 150° C. The copper wire used to lower the weighted bottle was marked off in feet, therefore the mid-depth of the pool was easily found. When the bottom samples were being collected, the apparatus was lowered gently till it touched the floor of the pool, then raised a few inches, drawn to one side, and the stopper temporarily lifted.

During transportation of the samples, ice-packing was ordinarily not needed, as the temperature out-of-doors was sufficiently cold to preclude any considerable change in the samples. Furthermore, but one or two pools were examined at a time, and the samples reached the laboratory within 30 or 40 minutes after collection. In all cases when more than two sets of samples were collected on one trip they were packed in ice.

I. QUANTITATIVE ANALYSIS

Treatment of samples.—The samples were plated in agar and gelatin, counts for colon bacilli were made in Jackson's peptone-lactose-bile medium[68] and in thirteen instances qualitative analyses were made for the detection of typhoid bacilli. In the results of a few preliminary tests it was found that the proper dilution of pool water to be made prior to implantation was 1 to 10 and 1 in 100, using normal salt solution as a diluent. In the "Kosher" baths on the Lower East Side of New York City, dilutions were made in various degrees, from 1 in 10, up to 1 of pool water, to 10,000 of salt solution, as the pollution of these pools was found to be exceedingly high.

In order to have the error, which usually attends the reading of pipets, equal for all tests, dilutions were so made that 1 c.c. could always be used for implantation. Few dilution tubes were made at one time, so that the volume might not be reduced by evaporation. It was noticed that immediately after sterilization the contents of the tubes had diminished slightly, due, no doubt, to the expulsion of dissolved air. The bottoms of the meniscuses of these tubes were therefore marked (prior to sterilization) immediately after which they were placed in the ice-box until used. As a rule these tubes resumed their proper volume upon warming and shaking, but frequently several had to be discarded.

Plating.—When plating, 1 c.c. of the sample or its dilution was added directly to the plates, the standard agar or gelatin being poured over. The inversion of the agar plates was effective in preventing the water of condensation from running over the surface, and little or no trouble was experienced because of surface spreading. Some bacteria cannot withstand, even for a short time, temperatures above 45° C., therefore in order not to destroy any of these more delicate organisms, the agar and gelatin were cooled to between 40° and 45° C.

68. *Jour. Infect. Dis.*, 1910, 7, p. 587; *Ibid.*, 1909, 6, 289; *Ibid.*, 1911, 8, p. 289; *Jour. Ind. and Eng. Chem.*, 1909, 1, p. 328; *Jour. Infect. Dis.*, 1907, *Supp.*, 3, p. 300; *Ibid.*, 1911, 8, p. 241.

before plating. Duplicate plates were poured for each dilution, and several dilutions were made for each sample. When any wide discrepancy occurred between counts of different dilutions for the same sample, the test was discarded. In selecting the final count to be recorded in the table, those from the highest dilutions were used.

II. QUANTITATIVE ANALYSIS

The method used in the detection of colon bacilli in water, one of the most important parts of the analysis, varies but slightly from that used and described before.[69] Jackson's lactose-peptone-bile medium was prepared and placed in fermentation tubes, which were given fractional sterilization for 3 days in the autoclave at 15 pounds pressure, instead of 15 minutes as recommended. When these tubes are sterilized in the autoclave, their contents frequently boil up, wetting the cotton plugs, and perhaps some of the lactose is hydrolyzed by the extreme heat. Five tubes and sometimes 6 were used for each sample. To each of the first two, 1 c.c. of the pool water, and to each of the remaining three, 1 c.c. of a dilution, were added. Twenty per cent of gas in the closed arm of the fermentation tubes was considered positive for the presence of colon bacilli. Many tests were made to verify this fact,[70] but when there was the slightest doubt, the tubes were re-examined. In the analysis of the inhibition of growth due to temperatures about 37° C., it was found that very little, if any, inhibition occurred up to 42.5° C. Therefore a separate incubator was run at 42.5° C. and all colon bacilli and typhoid bacilli[71] tests were made at that temperature. Inasmuch as each degree above 37° C. exerts additional inhibition to the growth of "water bacteria" it would seem that 42.5° C. is a better temperature than 37.5° C. for growth in all tubes for qualitative analysis.

CLASSIFICATION AND ARRANGEMENT OF MATERIAL

Of all the factors involved in the sanitary control of swimming pools, construction and equipment, source of water supply, etc., we have selected the factor of *administration* as the most convenient basis for classification. Accordingly we have divided pools into the following classes: (1) collegiate pools; (2) association pools; (3) public pools; (4) free floating baths; (5) Mikveh baths.

I. COLLEGIATE POOLS

The following three pools represent the most interesting and instructive group studied. It is in these pools that most of the experiments on technic and management have been worked out, and in their combined application an almost ideal procedure in the sanitary management of swimming pools is developed. The difficulties here

69. *Am. Phy. Ed. Rev.*, 1912, 17, p. 669.
70. *Ibid.*, 28, p. 588.
71. Careful and repeated examinations were made, by methods proved efficient in control, to isolate typhoid bacilli from the various pools. Since these were uniformly negative we will omit details.

encountered are far more amenable to control than those found in any other group.[72]

POOL 1

Water:. Filtered city water. Capacity, 50,000 gallons. Total water used per week, 200,000 gallons. Cost for water, $8.00 per week.

Management of water: Pressure filtration. Dilution: Pool half emptied each day. Entirely emptied twice a week, at which time thoroughly scrubbed.

Attendance: 800 per week, mainly college women, with a few elementary school boys.

BACTERIOLOGICAL EXAMINATION

A. Quantitative Analysis	Agar 37° C. per c.c.	Gelatin 20° C. per c.c.	B. Qualitative Analysis for Colon Bacilli per c.c.
Tap water (control)	40	400	0
Water from pool before use.....	70	1,130	0
After 9 hours' use by 125 women	3,400	Not made	Bet. 1-10
After 30 hours' use by 250 women	12,500	Not made	Bet. 1-10
After dilution following morning..	9,540	45,790	0
Evening same day	6,000	Not made	Bet. 1-10

Discussion: Relatively poor results for amount of money expended in running pool.

POOL 2

Water: Filtered city water. Capacity, 100,000 gallons. Total water used per week, 450,000 gallons. Cost of water per week, $14.00.

Management of water: Pressure filtration. Dilution: Constant stream of warm filtered water night and day, equivalent to four refillings per week. Pool thoroughly scrubbed once a week.

Attendance: 2,000 per week, mainly college men.

BACTERIOLOGICAL EXAMINATION

A. Quantitative Analysis	Agar 37° C. per c.c.	B. Qualitative Analysis for Colon Bacilli per c.c.
After 1 day's use by 400 men.....	300	0
After 2 days' use by 800 men.....	1,000	Bet. 1-10
After 3 days' use by 1,200 men.....	3,000	Irregularly present
After 4 days' use by 1,600 men.....	16,500	Irregularly present

TEST OF EFFICIENCY OF FILTER

	Agar 37° C. per c.c.	Gelatin 20° C. per c.c.	
Tap water (control)	13	192	Water murky
1 day's attendance..... 0	0	3	
2 days' attendance..... 0	20	10	
3 days' attendance..... 0	2	35	Water murky
4 days' attendance..... 0	160	280	

There were no colon bacilli present in 1 c.c. in any of the samples.

72. All bacteriological tests recorded throughout the following protocols are averages of three separate determinations.

Discussion: It was evident that the pool was in relatively good sanitary condition considering the large attendance. The filter, however, was worked beyond its capacity to clarify the water. It should be operated, therefore, more slowly. The cost of maintenance is unnecessarily high and can be reduced by methods described below.

POOL 3

Water: Filtered, refiltered city water. Capacity, 250,000 gallons. Water used for one or two months. Cost slight.

Management of water: Gravity sand filter, used for filtration and for refiltration. Anhydrous chlorin added in first series of tests, calcium hypochlorite in second. Pool filled once in two months, depending upon the results of appropriate tests.

BACTERIOLOGICAL EXAMINATION WITH ANHYDROUS CHLORIN

A. Quantitative Analysis	Agar 37° C. per c.c.	Gelatin 20° C. per c.c.	B. Qualitative Analysis for Colon Bacilli per c.c.
Tap sample (control)	20	60	0
After 7 days' use by 1,800 men A. M.	5	540	0
After 11 days' use by 2,100 men P. M.	50	600	0
After 8 days' use by 2,100 men A. M.	50	290	0
After 11 days' use by 2,400 men P. M.	60	520	0
Test from filter	5	410	0

BACTERIOLOGICAL EXAMINATION WITH CALCIUM HYPOCHLORITE

A. Quantitative Analysis	Agar 37° C. per c.c.	B. Qualitative Analysis for Colon Bacilli per c.c.
After 7 days' use by 2,100 men	800	0
After 11 days' use by 3,300 men	2,300	0

Discussion: The water was in excellent condition throughout use. Anhydrous chlorin and calcium hypochlorite were equally efficient in reducing bacterial pollution. Refiltration kept water so clear that smallest object was discernible on the floor of the pool. Cost of maintenance greatly reduced. Technic of this pool is recommended.

SUMMARY

The three preceding pools have much in common: they are all collegiate pools accommodating an intelligent clientele, they are well directed, and all have instructors present to prevent accidental drowning, and to insure obedience to the rules of cleanliness. Pool 1 uses plenty of water, derived from nightly dilution and bi-weekly fillings. Pool 2 maintains constant dilution night and day. Pool 3 retains the same water for months, but refilters and disinfects with chlorid of lime. The procedure of Pool 3 is far superior, from the view points of appearance of the water, economy of control, and sanitary condition. This condition was obtained by chemical disinfection and refiltration. The bacterial condition of the water of this pool closely approximated that of drinking water, which, after all, is the standard that should be set for the sanitary condition of swimming pools.

II. ASSOCIATION POOLS

The association pools are managed as the collegiate pools and accommodate the same class of attendance. By charging admission to the association, they insure a higher and cleaner class of patrons than the public pools which are described later. The technic in operating the different association pools is widely dissimilar and therefore very instructive. Many pools were examined but those that had similar technic and sanitary conditions approximately the same, have been omitted. The pools have been subclassified according to the number of weekly fillings.

POOLS FILLED DAILY

POOL 4

Water: Artesian well, not filtered. Capacity, 15,500 gallons. Cost for water = cost for pumping and heating.

Management of water: Daily filling and cleaning.

Attendance: 75 men daily.

BACTERIOLOGICAL EXAMINATION

	A. Quantitative Analysis		B. Qualitative Analysis for
	Agar 37° C. per c.c.	Gelatin 20° C. per c.c.	Colon Bacilli per c.c.
Test of well water	4	40	0
After day's use by 75 men	1,300	31,800	0

POOL 5

Water: Artesian well, not filtered. Capacity, 27,000 gallons. Cost of water = cost for pumping and heating.

Management of water: Daily filling and cleaning.

Attendance: 150 men daily.

BACTERIOLOGICAL EXAMINATION

	A. Quantitative Analysis		B. Qualitative Analysis for
	Agar 37° C. per c.c.	Gelatin 20° C. per c.c.	Colon Bacilli per c.c.
Test of well water	8	60	0
After day's use by 150 men	200	4,100	0

Discussion: Daily filling is satisfactory, but the cost of operation for large pools is prohibitive. Furthermore, the bacteriological conditions of these two pools were not so good as Pool 3, which depended not on frequency of refilling, but on refiltration and chlorination.

POOL FILLED THREE TIMES A WEEK

POOL 6

Water: Artesian well, not filtered. Capacity, 35,000 gallons.

Management of water: Pool cleaned three times a week.

Attendance: 250 men per week.

BACTERIOLOGICAL EXAMINATION

A. Quantitative Analysis	Agar 37° C. per c.c.	Gelatin 20° C. per c.c.	B. Qualitative Analysis for Colon Bacilli per c.c.
Tap water (control)	10	750	0
After day's use by 100 men	1,500	75,000	Bet. 1- 10
A. M. of second day	69,960	154,540	Bet. 1- 10
After 2 days' use by 250 men	2,200	292,500	Bet. 10-100

Discussion: The water in this pool was considerably polluted, in spite of frequent fillings. Growth of bacteria occurred after the first day's use. The growth consisted mainly of saprophytes (gelatin count at room temperature) though some increase is indicated in the bacteria which grow at incubator temperature. The increase in number of colon bacilli was due to bathers and not to growth. The sanitary condition of this pool is poor and should be corrected by methods indicated elsewhere.

POOL FILLED TWICE A WEEK

POOL 7

Water: City, filtered, refiltered. Capacity, 36,000 gallons.

Management of water: Refiltration. No chemical added to water. Cleaned twice a week.

Attendance: 15 persons per week.

BACTERIOLOGICAL EXAMINATION

A. Quantitative Analysis	Agar 37° C. per c.c.	Gelatin 20° C. per c.c.	B. Qualitative Analysis for Colon Bacilli per c.c.
Tap water (control)	52	197	0
Filtered water from pool	26	254	0
After 9 hours' use by 5 men	3,000	13,000	0
After 33 hours' use by 10 men	1,000	12,000	0
After 57 hours' use by 15 men	7,000	7,000	0
Pool filled every 10 days.			
After 7 days' attendance	110	1,300	Bet. 1-10
After 8 days' attendance	470	1,300	0
After 9 days' attendance	800	280	Bet. 1-10

Discussion: The sanitary condition was fair, but could have been made entirely satisfactory by the addition of calcium hypochlorite. It is clear from these tests that refiltration alone is not satisfactory in reducing bacterial pollution, although it is effective in removing much of the suspended matter.

POOLS FILLED ONCE A WEEK

POOL 8

Water: City water, not filtered. Capacity, 24,600 gallons.

Management of water: Pool thoroughly diluted on the third day (Wednesday). Cleaned once a week.

Attendance: 450 men per week.

BACTERIOLOGICAL EXAMINATION

A. Quantitative Analysis	Agar 37° C. per c.c.	Gelatin 20° C. per c.c.	B. Qualitative Analysis for Colon Bacilli per c.c.
Tap water (control)	150	190	0
After 1 day's use by 25 men	400	1,600	0
Before 3 days' use	24,440	11,440	0
After 3 days' use by 125 men	3,000	6,100	0
Before 6 days' use	200	7,600	0
After 6 days' use by 450 men	1,100	7,600	Bet. 1-10

Discussion: There was a gradual increase in pollution which was checked by the addition of the diluted water after the third day.

POOL 9

Water: City, filtered, refiltered. Capacity, 55,000 gallons.

Management of water: Constant refiltration. Constant dilution. Water from pool used for flushing toilets, urinals, etc., fresh water usually employed for this purpose added to pool instead. 145,000 gallons of water from pool used weekly. Hence pool practically filled two and one-half times per week.

Attendance: 1,300 men per week.

BACTERIOLOGICAL EXAMINATION

A. Quantitative Analysis	Agar 37° C. per c.c.	Gelatin 20° C. per c.c.	B. Qualitative Analysis for Colon Bacilli per c.c.
Tap water (control)	5	65	0
Pool water before use	43	42	0
After 12 hours' use by 250 men	200	50,000	Irregular
A. M. 48 hours' use by 500 men	120	360	0
P. M. 60 hours' use by 700 men	700	5,000	Irregular
A. M. 98 hours' use by 1,300 men	130	340	Irregular

Discussion: The good results obtained are due to refiltration and dilution. The use of a disinfectant, however, would eliminate the necessity for emptying the pool at the end of each week, and also improve the condition of the water.

POOL 10

Water: Double filtered city water. Capacity 32,500 gallons.

Management of water: Pool scrubbed once a week. Two feet of water drawn off daily and replaced with fresh water. Equivalent to about two fillings a week.

Attendance: 250 men per week.

BACTERIOLOGICAL EXAMINATION

A. Quantitative Analysis	Agar 37° C. per c.c.	Gelatin 20° C. per c.c.	B. Qualitative Analysis for Colon Bacilli per c.c.
Tap water (control)	11	480	0
Before use (from pool)	4	38	0
Used 48 hours by 70 men	310	1,380	0
Used 60 hours by 110 men	1,300	20,000	Irregular
Used 108 hours by 250 men	1,000	90,000	Bet. 1-10

Discussion: Plumbing should be modified for refiltration. Water was kept comparatively clear by double filtration.

POOLS EMPTIED ONCE IN TWO WEEKS

POOL 11

Water: City, filtered. Capacity, 55,000 gallons.

Management of water: Dilution water added at night in a quantity sufficient to account for fillings every 3 days.

Attendance: 6,000 men in two weeks.

BACTERIOLOGICAL EXAMINATION

A. Quantitative Analysis	Agar 37° C. per c.c.	Gelatin 20° C. per c.c.	B. Qualitative Analysis for Colon Bacilli per c.c.
Tap water (control)	5	36	0
Used 1 hour by 20 men.....	30	300	0
Used 12 hours by 500 men.....	700	6,000	Bet. 1-10
A. M. 96 hours by 1,000 men.....	4,000	44,000	Bet. 1-10
P. M. 108 hours by 1,500 men.....	2,500	150,000	Bet. 1-10
A. M. 210 hours by 3,500 men.....	2,600	150,000	Bet. 1-10
P. M. 222 hours by 4,000 men.....	5,000	170,000	Bet. 1-10
P. M. 300 hours by 6,000 men.....	1,400	31,800	0
Sample from filter (control).....	8	40	0

Discussion: It is obvious that sanitary measures are necessary to correct the needlessly high bacterial counts.

POOL 12

Water: City, filtered. Capacity, 90,000 gallons.

Management of water: Pool well filtered, clear throughout use. Can be arranged for three depths. Turkish baths (usually) taken prior to use of pool.

Attendance: 530 men in two weeks.

BACTERIOLOGICAL EXAMINATION

A. Quantitative Analysis	Agar 37° C. per c.c.	Gelatin 20° C. per c.c.	B. Qualitative Analysis for Colon Bacilli per c.c.
Tap water (control)	5	254	0
After 168 hours' use by 180 men...	150	350	0
After 180 hours' use by 200 men...	1,000	10,000	Bet. 1-10
After 360 hours' use by 450 men...	200	6,000	0
After 372 hours' use by 480 men...	200	1,000	0
After 384 hours' use by 480 men...	180	230	0
After 396 hours' use by 500 men...	300	3,000	0
After 408 hours' use by 500 men...	180	300	Bet. 1-10
After 420 hours' use by 530 men...	500	2,000	Bet. 1-10

Discussion: The reasons for this sanitary condition are: (1) The body of water is large as compared with the attendance; (2) enough dilution water is added to account for a little less than one refilling; (3) most of the bathers had taken Turkish baths prior to entering the water.

POOL 13

Water: City filtered, refiltered. Capacity, 33,000 gallons.

Management of water: Water was kept clear by refiltration. Pool scrubbed every 2 weeks.

Attendance: Variable; 700 attended during period of examination.

BACTERIOLOGICAL EXAMINATION

	A. Quantitative Analysis		B. Qualitative Analysis for
	Agar 37° C. per c.c.	Gelatin 20° C. per c.c.	Colon Bacilli per c.c.
Tap water (control).....	150	690	0
After 72 hours' use by 350 men...	200	25,000	0
After 108 hours' use by 700 men...	6,000	44,000	Bet. 1-10

SUMMARY

Pools that were filled once in two weeks showed varying sanitary conditions, depending upon the quality of the attendance, the amount of water offered per capita, the amount of dilution water, and the preliminary baths taken by the patrons. Undoubtedly the use of chlorid of lime, and of refiltration would improve these plants. The adoption of this technic is urged.

III. POOLS OPEN TO PUBLIC

Pools Nos. 14, 15 and 16 are open to the general public with no admission fee and no restriction, except good behavior. They are attended generally by a fairly good class of people. In the afternoons, mainly high school boys or girls bathe there; in the evenings, men or women. No instruction at public expense is attempted; the authorities merely open them and try to keep them clean. Men and women use these pools on alternate days. Pool 17, located in a high school, is also open to the general public in the evenings. During the day, however, it is maintained as a part of the regular instruction in physical training for the pupils.

POOL 14

Water: City, filtered. Capacity, 83,000 gallons. Filled every 2 days.

Management of water: Scrubbed four times a week. Women use the pool when first filled because of the ease with which gonorrhea may be contracted by women in polluted water. Cost of maintenance[73] $29,789.49 per annum. exclusive of the cost of water. Bathers must be clothed.

Attendance: 200 women, 1,600 men, daily.

BACTERIOLOGICAL EXAMINATION

	A. Quantitative Analysis		B. Qualitative Analysis for
	Agar 37° C. per c.c.	Gelatin 20° C. per c.c.	Colon Bacilli per c.c.
Tap water (control)	12	137	0
After use by 202 women.....	2,500	15,000	Bet. 1-100
After use by 1,600 men.....	400,000	600,000	Bet. 10-100

73. *Rept. Borough Pres. of Manhattan on Pub. Baths, New York City,* 1912.

POOL 15

Water: City, filtered. Capacity, 75,000 gallons. Filled three times a week.

Management of water: Women use pool when first filled. Pool scrubbed three times a week. Cost of operation, exclusive of cost of water, $29,170.82. Patrons must wear apparel in water.

Attendance: Women, 300 daily; men, 600 daily.

BACTERIOLOGICAL EXAMINATION

A. Quantitative Analysis	Agar 37° C. per c.c.	Gelatin 20° C. per c.c.	B. Qualitative Analysis for Colon Bacilli per c.c.
Tap water (control)	10	280	0
Filtered water	9	300	0
Used 1 hour by 20 women	50	7,000	Irregular
Used 15 hours by 300 women	3,000	50,000	Bet. 1-10
Used 38 hours by 600 men	20,000	60,000	Bet. 1-10

POOL 16

Water: City, unfiltered. Capacity, 90,000 gallons. Refilled three times per week.

Management of water: Same as previous pool, and in addition a "large handful" of chlorid of lime is added to water. The amount added is insufficient for disinfection. Wearing of apparel in water discouraged, though permitted.

Attendance: 200 women and 500 men daily.

BACTERIOLOGICAL EXAMINATION

A. Quantitative Analysis	Agar 37° C. per c.c.	Gelatin 20° C. per c.c.	B. Qualitative Analysis for Colon Bacilli per c.c.
Tap water (control)	20	80	0
After 13 hours' use by 200 women	25,000	31,000	0
After 48 hours' use by 200 women plus 500 men	85,000	160,000	Bet. 1-10

The practice of wearing clothing in the water is discouraged here, but insisted upon in Pools 14, 15. It would seem desirable for the practice in public pools to become standard. If clothing must be worn, it should be supplied by the authorities, with cleanliness guaranteed. The apparel worn by bathers frequently dyes the water. The expense of furnishing apparel could be eliminated by naked bathing for men. All the association, high-school, and collegiate pools maintain this practice with no noticeable ill effects.

The three pools discussed above (Nos. 14, 15 and 16,) are very similar in equipment, operation and sanitary condition. They fall into the same category because they are maintained at public expense, and their use is free of charge. No satisfactory methods for safeguarding the health of the patrons are employed and the use of chlorid of lime has been suggested, with the hope that this will effectively solve the problem.

These baths have been established to encourage swimming, as the death rate from accidental drowning is very high. Along the shores in fine weather, hundreds of persons, many nude, bathe in sewer-polluted water, risking personal health and safety. To offset this, the authorities established the free floating baths described later and the indoor plunges. The purpose of these baths and plunges, in addition to correcting the unsightly appearance of promiscuous and unlawful bathing from the docks, was to teach swimming to those anxious to learn. No instruction in swimming is given, however, and the very laudable purpose for which they were established has been defeated.

To correct this condition, a complete change in the administrative policy of these pools would be necessary. Our recommendations in this regard are: Instead of allowing the promiscuous use of these baths to any one, registration should be required, and a fee charged. At the time of application, the prospective pupil should be subjected to an examination by a physician of the Department of Health. If registration times were properly arranged in a season of the year when the physicians assigned by the Board of Health to examine school children were not busy, as for example during July, August and the beginning of September, and also several weeks throughout the year, these examinations could be given without incurring any additional expense. A set of rules should be given each applicant, covering the important items of sanitary conduct in the water, e. g., the importance of showering before and after bathing, and the importance of taking a sitz shower with soap (see summary), the danger from expectorating into the water, the importance of emptying the bladder before entering the pool, etc. Violation of these rules should result in expulsion, and forfeiture of the registration fee.

Each pupil should be assigned a convenient hour, and instruction in swimming should then be given. If, and upon good attendance, the pupil has learned to swim, his registration fee should be returned. On the other hand, if he attends irregularly, or fails to learn to swim after a stated length of time, there should be additional registration, and an additional fee charged. Separate hours should be set aside for all persons who can swim, registration should be required, but no fee charged. It is felt that at least two important purposes would be accomplished by this plan: (1) persons would be taught to swim, and others would be encouraged to attend who otherwise would never think of doing so; (2) some restriction on the admission of diseased persons to the pool would result. Many persons who are now afraid to enter the water, for fear of contamination, would be encouraged to do so by this plan.

POOL 17

This pool presents a problem unique in itself, and therefore needs separate treatment. It is patronized during the day by high school boys, being an integral part of their instruction in physical training; during the evening by the male public, over 16 years of age, without any restriction in, or any charge for its use.

Water: City, not filtered. Capacity, 24,500 gallons.

Management of water: Chlorid of lime added to water.[1]

1. (This pool was examined at a time when chlorid of lime was not added. The bacterial counts ranged above 100,000 per c.c. Between 10-100 colon bacilli per c.c. were usually present).

BACTERIOLOGICAL EXAMINATION

	A. Quantitative Analysis		B. Qualitative Analysis for
	Agar 37° C. per c.c.	Gelatin 20° C. per c.c.	Colon Bacilli per c.c.
Tap water (control).....	12	35	0
After 12 hours' use by 400 persons	1,000	20,000	Bet. 1-10
After 48 hours' use by 800 persons	5,000	75,000	Bet. 1-10
After 72 hours' use by 1,200 persons	800	35,000	Bet. 1-10

Discussion: This pool, even with the hypochlorite treatment, was not in satisfactory condition; the counts tho ordinarily not high, reached 163,360 per c.c. The technic of adding chlorin was poor and should be modified till a proper sanitary condition is obtained. The proper times to add the chlorid of lime are the following: In the evenings, after use by the general public, during lunch time, when no one uses the pool, and at 4 p. m. when the high school students are dismissed. The pool is not used between 4:00 p. m. and 7:30 p. m., thus affording an excellent opportunity for chemical treatment. The treatment should be controlled by appropriate tests, as described below, and would result in a much better condition of the water.

The use of the pool in the evening by the general public is subject to the same objections as described for pools Nos. 14, 15 and 16. No instruction in swimming is given, and no supervision of any kind to safeguard the health of the bathers is maintained. The attendance in the evening at the time of the examination did not exceed thirty, a number that could easily have been accommodated by Pool 14, which is in the vicinity. Radical change is here necessary to give a fair return to the city for the money expended, and to safeguard the health of high school boys. If this pool is to be continued and used, certain changes in administration and equipment are necessary. The use of the pool in the evening should be organized somewhat after the plan suggested for the previous three. Then again the pool should be deepened, as it is now so shallow that diving is dangerous. This could be done by building up the sides and utilizing the reconstruction for adding a combination life-rail and scum gutter, which is now absent. This would increase the cubic capacity of the pool, now insufficient. A filtering plant should be installed and so arranged that the water could be recirculated and refiltered in about six hours. The raising of the sides would not be difficult, and a ledge could be made sufficiently wide to permit the swimmers to stand upon it without danger. These recommendations are somewhat costly, but if carried out would rehabilitate an otherwise inadequate plant.

IV. OUTDOOR FLOATING BATHS OF THE CITY OF NEW YORK

The city of New York operates about 15 free floating baths, stationed during the summer at docks as far away from sewer outlets as possible. They are 95 feet long, and 60 feet wide, and are floated on 8 pontoons, four on each side. The peripheral parts of the pool and a balcony above are used for dressing rooms. The pool itself is divided into two parts, one 2.5 feet deep for children, and the other 4.5 feet deep for the adults. The average cost of construction of these

baths, twenty years ago, was about $12,000, and their cost of maintenance for the three months of their use averages $3,848.56.[74]

Observations as to their sanitary condition have been repeatedly made by the writer since 1910. Bacteriological tests were made in 1911, but since that time the authorities have become aware of the polluted condition of the baths, and it is hoped that in the near future some provision for their purification will be made.

The bacterial counts on gelatin ranged between 500,000-1,000,000 per c.c.; 100 colon bacilli per c.c. were always obtainable and the presence of free floating feces was frequently observed. Other debris from the sewers and from the many passenger steamers that pass up and down the Hudson and East Rivers can be found in these baths, but obvious pollution does not interfere with the patronage of the general public. The Metropolitan Sewage Commission[75] has pointed out clearly their unsanitary condition and recommends their abolition, but has not, unfortunately, made any recommendation for substitutes. "Bathing in free floating bathing establishments may be refreshing, and may give pleasure to the bathers, some of whom thus learn to swim, but the baths have little cleansing value. The water is unwholesome and even dangerous for bathing purposes. Floating particles of sewage enter many of the pools, even when situated 500 feet or more from a sewer outlet. When bathing, it is hardly possible to avoid accidentally taking some of the water into the mouth and nasal passages, and having it come in contact with the mucuous membrane of the eye. It is not to be doubted that bathing in such waters is a frequent source of infection. . . . As soon as possible the maintenance of free floating bath establishments should be discontinued."[76]

At the Baltimore convention on public baths when New York's floating baths were discussed, their remodeling into baths, using city (Croton) water, was urged. The cost of making the tanks water-tight and using water from the city main would be very great, and considering that such bathing establishments can be used only a few months in the year this expense seems unwarranted. The only excuse for floating baths, in place of the ultimately more economical indoor pools, is the prohibitive cost of land in the crowded districts of New York, where such baths are needed. Floating baths, if they must be used, should be made water tight, and the water from the river pumped in and filtered. In conjunction with the filtration, which should be effective in removing suspended matter, bleaching powder should be added to the water in an amount controlled by tests and sufficient to destroy all bacteria not retained by the filters.

Inasmuch as such baths are available only for a short time of the year, and as the expense of their remodeling would be great, it would seem that the establishment of public indoor pools on the end of the recreation piers would be ultimately more economical. It is the present policy of New York to increase its recreation facilities, and the erection of more public piers, with pools at one end, would not be difficult. These pools could form a regular part of the recreation equipment, and water from the river could be pumped into them, filtered, purified by chlorid of lime, and heated during winter, so that their use might become permanent. River water[77] should be used, largely because

74. *Rept. of Borough President of Manhattan on Public Baths, New York City,* 1912, p. 10.
75. *Rept. of Metropolitan Sewage Com.,* New York City, 1908-10.
76. *Rept. of Metropolitan Sewage Com., New York City,* 1910, p. 82.
77. With the opening of the new Catskill aqueduct, New York City will be supplied with a superabundance of water. It will be cheaper and better at that time to use city water and add sea-salt to any desired concentration. Prof. W. H. Park suggested this and also that the cost of sea-salt would be far less than that of chlorid of lime.

of economy. Some writers, however, believe that salt baths are preferred by the people, which fact, together with the previous one, forms sufficient arguments for the use of river versus Croton water.

V. MIKVEH PLUNGES OF THE LOWER EAST SIDE OF NEW YORK

The attention of the writer was directed to these pools by H. F. J. Porter, M. E. industrial engineer, who believed that additional investigation and publicity would be productive of much good. All the data collected and used by him in the preparation of a comprehensive paper on this subject were turned over to the writer and used as a comparison and control with the data reported in the table below.

These pools are patronized by the Jewish people of the lower East Side of New York City. At certain times in the year (e. g. the Passover) their use is compelled for both men and women. Religious law, for example, forces the women to use these pools within seven days after menstruation. The Hebrew law[78] is very strict, stating that after thorough cleansing, the person should immerse himself or herself in a purified plunge filled with uncontaminated water, i.e., rain water, ice-water, or water that had not been polluted by human beings, and that this plunge should contain at least three cubic yards of water.[79] These excellent laws are not carried out. The men and women in their respective pools wash themselves in polluted water, in plunges with about 200 cubic feet capacities, and which are sometimes used by 300 different individuals without change of water. In connection with some of these Mikvehs there are either tubs or shower-baths, but neither of these is frequently patronized because of an additional charge of five cents for use. Hence the same water through constant use becomes contaminated and in no sense fulfils the requirements of the Biblical law.

Number of Mikvehs having between	
100- 1,000 bacteria per c.c.	2*
1,000- 10,000 bacteria per c.c.	7
10,000- 50,000 bacteria per c.c.	4
50,000- 100,000 bacteria per c.c.	3
100,000- 200,000 bacteria per c.c.	7
200,000- 500,000 bacteria per c.c.	3
500,000-1,000,000 bacteria per c.c.	4
1,000,000- or over bacteria per c.c.	11
Total plunges examined	41

78. *Bk.* 3, *Ch.* 1, *p.* 11 *of* Levit.

79. Biblical data furnished me through the courtesy of Rabbi Ch. Hirschensohn of Hoboken, New Jersey.

Number of Mikvehs having between	
0- 0 colon per c.c.	3*
0- 10 colon per c.c.	7
10- 100 colon per c.c.	6
100- 1,000 colon per c.c.	13
1,000-10,000 colon per c.c.	11
10,000-or more colon bacilli per c.c.	1
Total	41

*Attendance less than 3.

Forty-one of these baths were examined in 23 different buildings.[80] There are usually, in one building, several plunges containing water at different temperatures. The bathers go from the lower to the higher temperatures where they remain for several minutes till they have sweated thoroughly, thus removing most of the dirt. When sweating-rooms are provided, bathers often prefer to use them in place of the Mikvehs. The temperatures of these plunges range from 18°-50° C. After use the water is thick, slimy, and unpleasantly odorous. The average attendance varies, in several instances 80-100 persons bathed in 200 cubic feet of water, while in one instance 300 persons used a slightly larger pool.

There can be small wonder, therefore, at the very large bacterial findings. Counts on gelatin ranged from 1,000 to 3,000,000 bacteria per c.c. and counts on agar were as high, in fact, in one instance they reached 18,144,000 bacteria per c.c. The counts for colon bacilli are interesting and astonishing. In the instance where 300 persons had used the water the colon count was 10,000 per c.c. The temperature of this pool (50° C.) was sufficiently high to continuously destroy colon bacilli. The large number were present in spite of this fact.

That these pools are a serious menace to the health of the people using them is clear. Radical measures to improve their condition or to substitute other means of ablution should be immediate. This neighborhood on the lower East Side is extremely crowded, and the tenements are not equipped with bath-tubs. The people of these districts, therefore, must depend either upon the very few public baths established in these neighborhoods or these unsanitary Mikvehs.

In spite of the fact that these Mikvehs do not comply with the Mosaic Laws, their abolition would be strongly opposed by the Jewish people who bathe there. The writer believes that the following recommendations could be made which would insure cleanliness and at the same time permit the exercise of the required religious ritual:

1. The basements of public schools could be modified into public shower-bath rooms. The authorities of many foreign cities finding this method successful have encouraged the use of these baths not only as a regular part of the elementary school instruction, but also as a means of bathing for the general public. Such baths have been established in several public schools in New York City, but the use of these has been restricted to students. Shower-baths for adults would be in beneficial competition with the Mikvehs, especially if the baths were free of charge. That this plan is feasible and economical is unquestionable. It is preferable to the erection of new buildings because of the high

80. An inspector of the Department of Health of the City of New York was assigned by courtesy of the Commissioner to accompany us. Mr. Kranz acted as interpreter.

cost of land, the cost of erection, and the duplication of running expenses, such as the salaries for janitors, cleaners, etc. The basements of public schools are at present frequently used as playgrounds for which purpose the roof would be far superior. The use of the basements or parts of the basements, in the evenings, for shower-bath rooms would be a great benefit to the people of these crowded districts and would reduce the cost of public baths.

2. Jewish charities should be encouraged to establish sanitary bathing places free of charge, either in connection with Synagogues or elsewhere.

3. Settlements in the vicinity should make an effort to install showers for the adults of the neighborhood.

4. The authorities of New York City should pass sanitary regulations with which the proprietors of these establishments should comply in order to have their licenses renewed. Because a fee is charged these baths are licensed by the city, and through this licensing power the city can compel the enforcement of sanitary laws. Such laws should include the following requirements:

A. All Mikveh plunges should be abolished, because of their unsanitary and polluted condition. Mikvehs consisting of individual tubs might be substituted in their place.

B. Shower-bath establishments, with or without sweat-rooms, because of their cleaner nature, should be approved. The reduction of their license fee might encourage their increase.

C. All individual tubs should be cleansed after each bath. Failure to observe this precaution should cause forfeiture of license.

SUMMARY AND CONCLUSIONS

The literature on swimming pools shows that a number of maladies —infections of the eye and ear, gonorrhea, and intestinal diseases— may be transmitted through the water in the pools. Since typhoid fever is endemic in New York City, the danger of a typhoid carrier contaminating a pool is not remote. Therefore an accurate determination of contamination with intestinal bacteria is one of the most important indices to the sanitary condition of a swimming pool.

The present investigation has included examinations of five distinct types of swimming pools, all of which will be briefly discussed below.

I. Collegiate pools in the city of New York are in very good condition, owing to the careful supervision of the plants by the professors in charge, the knowledge of sanitation of the swimming pool possessed by its patrons, and finally because of the enforcement of the sanitary regulations by swimming teachers.

II. Association pools were divided into groups according to the number of weekly refillings. Those that were emptied daily were in good condition. The value of daily filling, however, is inferior, from a sanitary point of view, to refiltration and chlorination, and from an economic point of view, too costly. The pool emptied three times a week was in poor sanitary condition on the second day of use.

Chlorin should be added daily. The installation of a filter at a cost of $500 would be an eventual economy.

In the pool emptied twice a week with refiltration practiced the use of a disinfectant was necessary. Refiltration unaided by chlorination is not a satisfactory method for the sanitation of swimming pools.

Among the pools emptied once a week, Nos. 8 and 10 needed refiltration and chlorination. Pool 9, in which refiltration was practiced and considerable dilution water added, was located on the top floor of the building. The water used to flush toilets and urinals and for all other waste purposes was subtracted from the pool and fresh water added in its place. This plan deserves imitation. The use of small amounts of chlorin here would put the finishing touches on an almost ideal pool.

In the three pools that were emptied every two weeks, Pool 11 could have its plumbing modified and refiltration installed at an expense of $70; the excellent condition of Pool 12 was due to the fact that a large amount of water was used for a relatively small attendance and also members always took a careful preliminary bath and frequently Turkish baths; Pool 13, though maintaining a clear water by refiltration, required disinfection, an additional proof that refiltration unaided is not a sufficient means of maintaining a sanitary condition of the water.

III. Public pools in New York city are elaborately equipped and generously operated, but because of their large and promiscuous attendance, faulty technic and improper organization, they are possible sources for the spread of disease.

A much better condition of the water could be obtained by the use of chlorid of lime, the addition of considerable dilution water, and frequent refillings, or by the combination of chlorination and refiltration.

These plants would be of greater service if they were reorganized, all prospective pupils registered and examined by physicians of the department of health, diseased persons barred from admission, and instruction in swimming given.

IV. An examination of free floating baths in New York city showed the sanitary condition to be so poor as to warrant their abolition or immediate remodeling. If remodeled, they should be enclosed, made water-tight, and the river water pumped through a filter into them.[81]

81. See foot-note 76.

Inasmuch as filtration would not sufficiently reduce the bacterial pollution, the water should be subsequently disinfected with chlorid of lime. These floating baths can be used only a few months in the year, are, comparatively speaking, inaccessible, and are inferior in every way to the more attractive indoor plunges which can be used the whole year. The only excuse for these establishments is the saving in the cost of land, which is excessive in the crowded districts where they are most needed. The cost of constructing new indoor pools on the ends of the piers would be no more than the cost of remodeling the old scows into water-tight boats. This plan of establishing pools at the end of the recreation piers would be feasible and economical because:

1. The policy of the city in pursuing its plan of recreation, is to increase the number of these piers, which are already numerous.

2. There would be no extra cost of land, no extra cost of janitorial fees, and the cost of remodeling old scows would be as great, if not greater, than the cost of building model plunges on land.

3. The river water in which the people delight to bathe could be pumped in through a filter and subsequently disinfected.

4. The instruction in swimming could be correlated with the plan of recreation, and this instruction maintained the year round.

5. These pools would cost less to operate than the present public plunges. Water could be used more lavishly, and the pools operated throughout the entire year.

6. The cost of berths (docking fee) for floating baths would be saved.

V. Mikveh plunges in New York city are not sanitary and bathing in them menaces the health of the people. Jewish people in this vicinity wish them both for religion and for cleanliness, but the manner in which they are operated defeats these purposes. Individual tubs or Mikvehs to be cleansed after each bath, should be constructed in place of plunge Mikvehs. Licenses should be granted by the city, only after inspection shows entire compliance with any new sanitary laws.

Inasmuch as the tenements of this vicinity have no bathing facilities, the basements of public schools should be remodeled into shower-bath rooms. Settlements in the district should open shower rooms to accommodate the adult population of the neighborhood, and Jewish charities should be urged to provide adequate accommodations for the

baths of their people. Synagogues should build Mikvehs that comply with the sanitary intent of the old Mosaic laws.

In view of the large number of plunges in New York city, and of their various sanitary conditions, an officer of the department of health should be appointed to supervise them. He should examine their sanitary conditions, grant licenses and approve or modify their methods of operation.

So far we have made many recommendations which we believe would tend to improve the conditions found in individual plants. We wish to summarize finally, general recommendations which we feel certain should be observed in all pools whatever their location or administration.

GENERAL RECOMMENDATIONS

1. *Construction and equipment.*—Pools should be constructed of smooth lining without crevices and should be of as large capacity as possible. There should be no obstructions of any kind in the water, a combination of life-rail and overflow ledge making this possible. Where feasible, the plunge should be constructed on the top floor of the building so that the water used for flushing purposes could be taken from it. The fresh water usually employed for this purpose should be added to the pool instead. Each establishment should be provided with adequate shower baths and convenient dressing rooms and toilets.

2. *Source of water supply.*—The water used in swimming pools should be pure. Where this is not possible it should be thoroughly purified before use by the methods indicated.

3. *Management of the water.*—The water should be thoroughly filtered before passing into the tank, so that the opacity of the water could not obscure a submerged person. The water should be changed frequently, and as much dilution water added as possible. These two procedures in themselves, however, are of little importance if refiltration and chemical disinfection are used.

Refiltration is an efficient and economical method of keeping water clear during protracted use.

4. *Chemical disinfection.—Calcium hypochlorite, used in amounts controlled by appropriate tests, has been shown to be efficient for the disinfection of swimming pool water, and its application to the water, in conjunction with refiltration is urged as a most effective method of*

pool sanitation. There are two simple ways of adding the chemical to the water: (1) Small cheese-cloth bags containing the hypochlorite may be strung along a pole of sufficient length to reach across the pool, and then dragged back and forth till the contents are dissolved. At the end of a half hour, the amount of chlorin remaining in the water should be measured (as previously described) by the man in charge. In the event of too much chlorin being added, the water of the pool might be diluted by sending in a stream of fresh warm filtered water. If too little hypochlorite has been added, the process of treatment should be repeated. (2) If the pool is to be subjected to refiltration the above procedure could be modified and simplified; instead of treating the pool by means of cheese-cloth bags, a small mixing and feeding chamber could be made and attached to the intake pipe, and the water after refiltration, continuously treated with hypochlorite. The question[82] arises whether or not the slow gradual addition of the chemical is as efficient as is the rapid periodic method. With the slow method, the concentration of the hypochlorite is never great, while with the rapid, the sudden increase of the chemical concentration is sufficient to cause rapid bacterial destruction. When the chemical is added slowly, however, the time of its contact with the bacteria is accordingly prolonged, and this explains the equality in the efficiency of both methods.

Comparing pools where one or the other method is employed we find that the slow gradual addition of the chemical seems to be superior. This latter method also, however, should be controlled by tests. The attendant in charge, therefore, should take samples for examination; the amount of chlorin in the water will indicate to him its approximate purity, and should there be any unusual deviation from the reaction described below, it can easily be corrected. This method of using refiltration and chlorination appears to the writer to be the better, for the following reasons: (1) the clarity of the water throughout use would be maintained, and its sanitary condition improved; (2) the water could be used for several weeks, with an elimination of the necessity for cleansing the floor and sides of the pool, at the same time cutting down the great waste of water, and the amount of coal used for heating purposes.

A simple method for testing the amount of chlorin in water is as follows: To a liter of water in a flask, held over a white tile, should

82. This question was suggested to Professor Park.

be added a mixture containing a crystal of iodid of potassium, a few drops of acetic acid, and a teaspoonful of starch.[83] The proper end reaction to be obtained is a violet blue; if a darker color is obtained, too much chlorin is present, if a lighter, not enough is present.[84]

After emptying the pool, its floors and sides should be washed with antiseptics (chlorid of lime, formalin, etc.), as pools not employing this precaution are frequently polluted prior to use.

5. *Administration.*—Students and patrons should be subjected to physical examinations before admission to the plunge, and all diseased persons excluded. A set of rules should be given covering the important items of sanitary conduct in the water, e.g., the importance of showering before and after bathing, the importance of taking sitz-showers[85] with soap, of abstaining from expectorating into the water, the importance of emptying the bladder before entering the pool, etc. Patrons and students should be compelled either to bathe nude, or to use clothing the cleanliness of which has been approved by the director.

In a plant properly managed the filters during use should be frequently reversed, thus washing the accumulated dirt into the sewer. When filling the pool, reversing every hour is usually found necessary. When refiltering the water from the pool, the reversing at least twice a day is necessary. The workmen in charge of the filtering plant and those employed to clean the pool, should be carefully supervised.

The writer wishes to express his gratitude to both Dr. Hans Zinsser and Dr. Augustus B. Wadsworth, for the material aid given him in the preparation of this paper.

83. The iodo-starch reaction is sufficiently delicate to indicate the presence of one part of chlorin in ten million parts of water.

84. *Jour. Roy. San. Inst.*, 1910, 31, p. 281.

85. The showers taken by swimmers, prior to entering a pool, are hardly sufficient to wash from their bodies the harmless saprophytes that are on their skin, and some method of washing the perineal regions should be employed. A simple perforated ring through which water could be made to flow or which would cause water to flow automatically when pressure is exerted on the ring might be satisfactory. As far as the writer knows, no arrangement of this kind has been devised.

VITA

Wallace A. Manheimer, born New York City, February 13, 1887; graduated College of City of New York, 1908, with the degree of B.S. and Columbia University, 1912, with the degree of A.M.; author of "A Study of the Sanitary Conditions of Indoor Swimming Pools," American Physical Education Review, December, 1912.

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